Optimal Reactive Power Control in Renewable Energy Sources: Comparing a metaheuristic versus a deterministic method

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Renewable energy sources such as photovoltaics and wind turbines are increasingly penetrating electricity grids. Through the use of inverters they can aid in the compensation of reactive power when needed, lowering their power factor. In this study, 3 different optimization scenarios where reactive compensation is needed are considered. We tested the performance of a deterministic and a metaheuristic algorithm in solving the optimization problems. The metaheuristic algorithm located a better optimal point in a scenario where many optimal points existed (real loss minimization), while the two algorithms presented similar results in the other two scenarios (substation reactive supply minimization and voltage deviation minimization).

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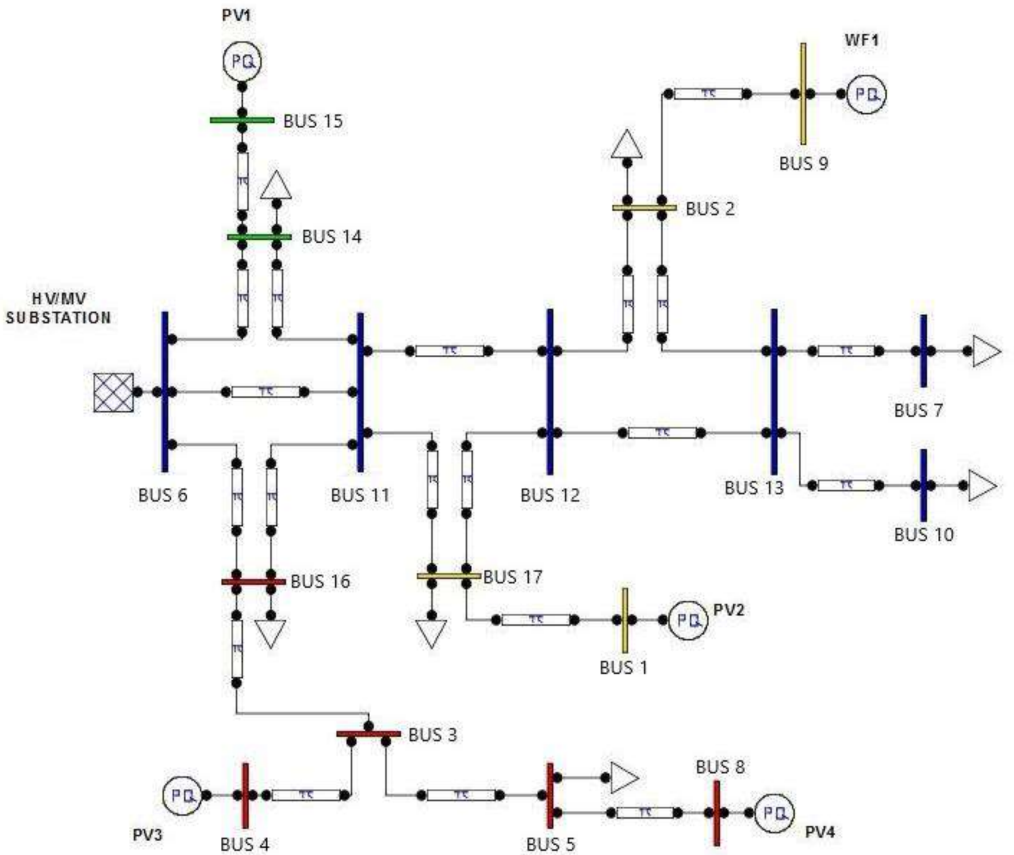
Network Topology

- Based on actual grids in Greece
- 17 buses
- 20 lines
- 7 loads
- 5 RES consisting of 4 PV farms (~100kW) and one small wind turbine (~800kW)



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Optimisation Algorithms

Modified Barrier Lagrangian Function

- Newton based
- Deterministic algorithm
- Handles Constraints

Implemented in PSAT

Particle Swarm Optimisation

- Metaheuristic Algorithm
- Better fit for functions with unknown convexity
- Can’t handle constraints natively

Implemented with PandaPower

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Optimisation Scenarios

- Technical Loss Minimisation

$$\Phi_{RL} = \sum\sum g_{km}\left[V_{2k} + V_{2m} + 2V_kV_m\cos(\theta_k - \theta_m)\right]$$

- Substation reactive power supply minimization/target

$$\Phi_{SQ} = (Q_{Sub} - Q_{Setpoint})^2$$

- Bus voltage targets

$$\Phi_{VS} = \sum(V_k - V_{Setpoint})^2$$

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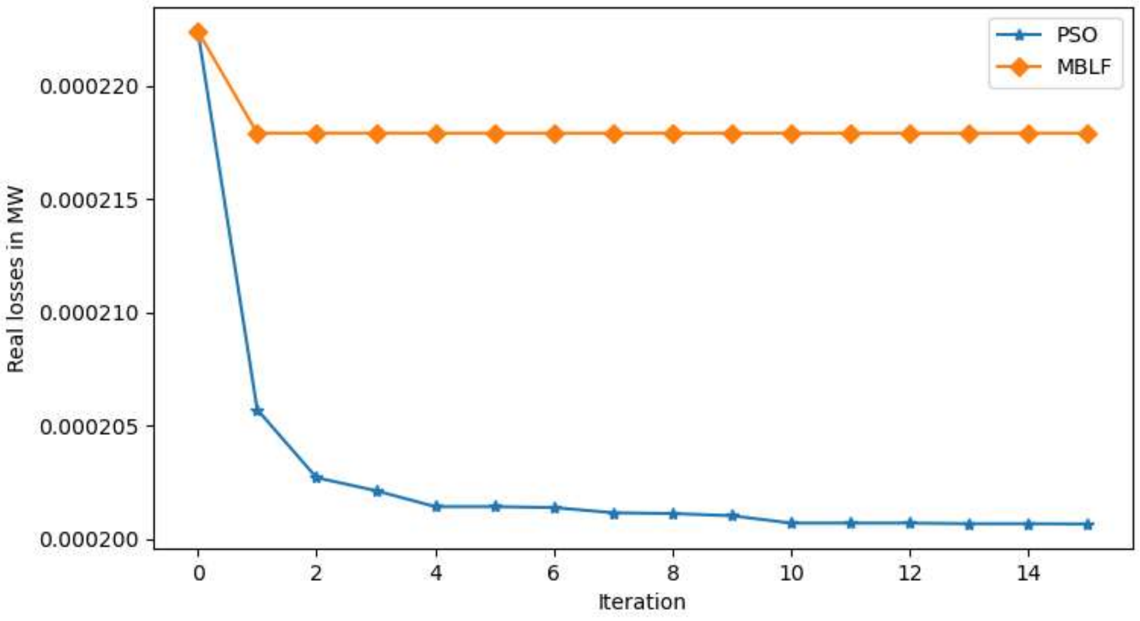
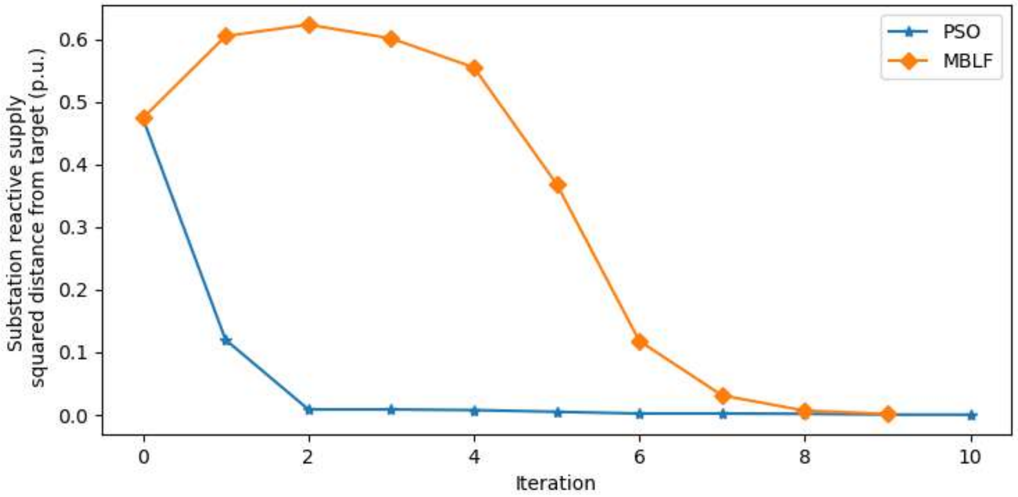
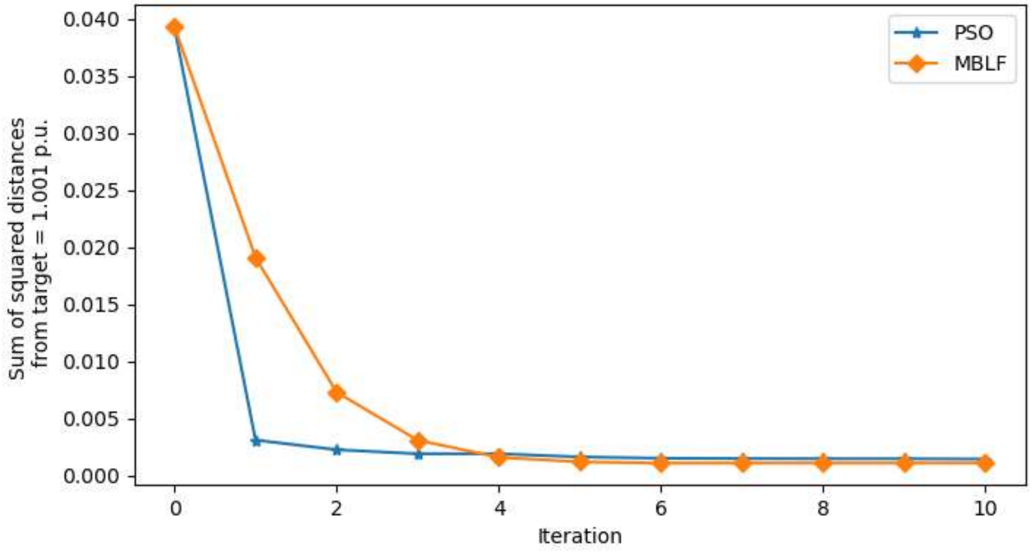
Results







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Conclusions

- PSO achieved more than double (~10% vs ~4%) in power loss reduction
- Similar results in the other two scenarios
- MBLF handles problem with a single optimum
- PSO more likely to find the global optimum in functions rid with local optima

Limitations

- Inequality constrains were unrealistic to better facilitate algorithm benchmarking
- No low voltage region due to added complexity & platform compatibility (PSAT & PandaPower)
- Legislation framework

Future

- Testing in real life systems like iDERgridy or iReact